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Calspan Corp, Buffalo, NY

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System for Applying Powdered Gelling Agents to Spilled Hazardous Materials

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SYSTEM FOR APPLYING POWDERED GELLING AGENTS TO SPILLED HAZARDOUS MATERIALS

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This report is a product of the above efforts. It documents the design, fabrication and field demonstrations conducted to develop a system for applying multipurpose gelling agent to hazardous material spilled on land. As such it serves as a reference to those in state, local and Federal Agencies and the transportation and chemical industries, and others who are interested in the control of spills of hazardous materials. This project is part of a continuing program of the Oil and Hazardous Materials Spills Branch, IERL-Ci to assess and mitigate the environmental impact of pollution from hazardous material spills.

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

Research had been conducted to develop a blended material that would optimally immobilize a wide range of liquid chemicals detrimental to the environment. The product of this research was Multipurpose Gelling Agent (MGA), a blend of four polymers and an inorganic powder. When applied to a chemical spill, MGA turns the hazardous liquid into a gelatinous mass which can be easily removed by shovel or other mechanical means.

The MGA research program has also included design, fabrication, testing, and demonstration of a mobile, self-powered, mechanical system for dispensing powdered MGA to spill target areas in a safe and effective manner. A prototype of the Mobile Dispensing System (MDS) was constructed and tested. The MDS unit incorporates an auger-fed pneumatic conveyor system and a trailer that can be towed to remote spill sites. After initial testing to determine the MGA range and dispersal pattern, the MDS unit was tested against both small- and large-scale simulated spills. On 4 November 1976, the MDS unit was demonstrated for a group of USEPA officials at a Calspan test facility in Bethany, New York. It was subsequently delivered to the USEPA Industrial Environmental Research Laboratory, Edison, New Jersey.

This report was submitted in fulfillment of Contract No. 68-03-2093 by Calspan Corporation under the sponsorship of the U.S. Environmental Protection Agency. The report covers a period from 24 June 1976 to 26 July 1977; technical efforts were completed in July 1977.

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ABBREVIATIONS

MGA (Multipurpose Gelling Agent)

MDS (Mobile Dispensing System)

Metric Unit	Comparative English Units
atmospheres (atm)	pounds per square inch (psi)
centimeters (cm)	inches (in.)
cubic centimeters displacement (cm^3)	cubic inch displacement (cu. in.)
kilograms (kg)	pounds (lb)
kilowatts (kW)	horsepower (HP)
liters	gallons (gal)
liters per minute (liters/min)	gallons per minute (gallons/min)
meters (m)	feet (ft)
kilometers per hour (km/hr)	miles per hour (mph)

SECTION 1

INTRODUCTION

Under sponsorship of the U.S. Environmental Protection Agency (USEPA), Calspan Corporation has developed a mechanical system for delivering Multipurpose Gelling Agent (MGA) to areas endangered by chemical spills. Development included the determination of equipment needed to build a Mobile Dispensing System (MDS), design and construction of a functional MDS prototype, and testing and demonstration of the MDS prototype under field conditions.

MGA is a polymeric blend absorbent, developed by Calspan for USEPA under Contract No. 68-01-0110, that immobilizes liquid chemical compounds detrimental to the environment.[1] When MGA is applied to a chemical spill, it interacts with the hazardous material to produce a gelled form that can be easily removed by mechanical means. This immobilization reduces the area damaged by the spill, arrests percolation of toxic liquids into subsoils, and prevents chemical flow into surface and subsurface waters.

The initial objective of the research program was to determine a gelling agent formulation that would provide an optimum balance of rapid congealability, easy application, and low production cost. To produce this optimum balance, Calspan tested various MGA formulas on 35 hazardous liquid compounds. For testing purposes, each compound was classified as either an aqueous, nonpolar organic, polar organic, or alcoholic material. Testing showed that a formulation called Blend D, consisting of four polymers and a fumed silica, was the optimum gelling agent. Each of the four polymers tested was capable of congealing at least one class of hazardous liquids.

In the development of MGA, an economic evaluation showed that the physical form of MGA controlled its overall cost. A powdered form was chosen because it was easier and less costly to produce than the alternatives considered. However, this form does have a disadvantage in that more powdered agent can be lost during windy conditions.

A second objective was to investigate mechanical systems for dispersing powdered agent in a safe and efficient manner. The MDS investigation consisted of determining which commercially available, "off-the-shelf" equipment was suitable for use in the MDS unit and developing concepts and recommendations for implementing a system for dispensing the agent. Results of research devoted to these goals are presented in USEPA Report No. EPA 600/2-77-151.[2]

Upon completion of this research, the contract was amended to permit

design and fabrication of a functional, self-contained MDS prototype. Also included were the required field testing and demonstration of the MDS prototype and supporting documentation covering maintenance and operation of MDS. In addition to this report which summarizes work performed on the contract amendment, documentation included the production of a slide presentation and a 10-minute film on MDS capabilities.

Development and testing of the MDS prototype fulfilled three main tasks of the overall MGA program:

Task I	To design and construct a mobile self-contained dispensing system for MGA
Task II	To acquire and blend individual gelling agent components to prepare approximately 1204 kg (2655 lb) of MGA
Task III	To test the mobile MGA-dispensing system with MGA on a variety of large and small field spills

The completed prototype unit and operational manual were delivered to the Edison research laboratory in May, 1977.

SECTION 2

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY AND CONCLUSIONS

Under USEPA sponsorship, a Mobile Dispensing System (MDS) was designed for delivering Multipurpose Gelling Agent (MGA) to hazardous chemical spills in a safe and efficient manner. In fulfillment of Contract No. 68-03-2093: Amendment 4, an MDS prototype was constructed and tested. The system consists of a hydraulically driven, auger-fed/pneumatic conveyor powered by a gasoline engine, requiring no external power source. The component parts of the system were housed in a 4-m (12-ft) utility trailer, which can be towed to spill sites by a three-quarter ton tow vehicle.

The MDS unit was tested to determine its range and dispersal pattern with powdered MGA. Very efficient coverage occurs in low wind conditions, e.g., ∿8 km/hr (∿5 mph). When the exit hose is held 1.2 m (4 ft) above the ground in a horizontal position, 85 percent of the MGA is delivered over distances from 2 to 6 m (6 to 20 ft).

As wind velocity increases, the fraction of powder blowing out of the target zone increases.

Effective operation can be maintained by directing the powder down into the spilled material.

On 4 November 1976, the MDS prototype was demonstrated under field conditions against small-scale chemical spills and a simulated major liquid spill. Based on field demonstration results, it was determined that the MDS prototype delivers MGA at a rate of at least 5.4 kg (12 lb) per minute and can be successfully used for treating both stagnant and flowing spills.

The MDS prototype delivered to USEPA provides a working mobile system for dispensing MGA that is easy to tow into remote locations. Built from readily available commercial equipment, the MDS unit is capable of treating both large and small chemical spills so that they can be easily handled by mechanical means. To operate the MDS unit, a minimum of two personnel are required. Operators do not require extensive training to apply agent effectively.

MGA powder was successfully tested against compounds representing most major chemical types. One kilogram (2 lb) of agent generally can gell 10 liters (2.6 gal) of spilled liquid.

Since the operation of the MDS involves the use of powdered agent, appropriate dust masks and other protective equipment must be worn by spill-response personnel in its vicinity.

RECOMMENDATIONS

Further testing of both MGA and the MDS should be conducted by spill teams and local fire departments. Subsequent testing should include applying MGA to a simulated large-scale chemical spill of 7,600 to 19,000 liters (2,000 to 5,000 gal). The MDS unit should also be tested using other forms of MGA, including the roll compressed form, other adsorbent powder chemicals, and powdered neutralizers for acidic or basic spills.[2]

MGA powder can be blown off target depending on wind conditions. Toxic vapors can also be carried into the MDS area. Because wind direction and velocity are critical for effective and safe treatment, the MDS design should be modified to include wind monitoring equipment.

Other treatment materials and equipment, such as urethane plugs, diking foams, and containment bags, should be added to the MDS unit to expand its landspill control capabilities.

Subsequent investigation should examine methods for recovering spilled chemicals from the gelled form and effective means for applying MGA over broad chemical spill areas up to 1 hectare (2.5 acres).

SECTION 3

DESIGN AND FABRICATION

Based on preliminary work done under EPA Contract No. 68-03-2093 on "Multipurpose Gelling Agent and Development of Means of Applying to Spilled Hazardous Materials," a powdered form of MGA was chosen for this program. Powdered MGA provides a surface area greater than that for the alternative forms considered, thereby achieving quicker reaction time with spilled liquids.

DISPERSING SYSTEM SELECTION

In evaluating dispersion systems for powdered MGA, four alternatives were considered. These alternatives included (1) a pressurized tank, (2) a Venturi/compressed air combination, (3) a centrifugal blower, and (4) an auger-fed/pneumatic conveyor.

Because the auger-fed/pneumatic system showed the most promise of dispensing MGA in a safe and effective manner, it was selected as the dispersal component for the Mobile Dispensing System (MDS).[2] In addition to its increased load-delivery capacity and its efficient MGA dispersal volume, the auger-fed/pneumatic system can be powered by either a DC motor or a gasoline-driven engine, making it ideal for portable field application.

EQUIPMENT SELECTION

The auger-fed/pneumatic conveyor system selected for the MDS was a Bantam 400 Rockduster (Mine Safety Appliances; Pittsburgh, Pennsylvania). The unit has a hopper which auger-feeds MGA into a moving airstream, fluidizing the agent and transporting it through a 5-cm (2-in.) ID delivery hose for distances of approximately 60 m (200 ft). In preliminary testing, using a 30-m (100-ft) section of exit hose, the Rockduster lost less than 20% of the MGA load to wind effects.

In its off-the-shelf configurations, the Bantam 400 Rockduster distributor can be powered by either a 440-volt, 2.7-kW (5-HP), direct current (DC) electric motor or by a hydraulic oil flow of 49 liters/min (13 gallons/min) at 68 atm (1000 psi). Since it was required that the MDS design be completely mobile and operable without external power sources, the Rockduster model selected was hydraulically powered using a K-series 31.8 cm^3 (1.94 cu. in.) per revolution displacement, single-stage hydraulic pump (Webster Electric Company, Inc., Racine, Wisconsin). This hydraulic pump is driven by a 22.4-kW (30-HP) air-cooled gasoline engine (Teledyne Wisconsin Motor, Milwaukee, Wisconsin). The engine has a four-stroke,

1.76-liter (108-cu in.) piston displacement with 12-VDC electric starter, alternator and 23-liter (6-gal) fuel tank. This power supply incorporates a 151-liter (40-gal) hydraulic oil reservoir (Hydrocraft, Inc., Detroit, Michigan).

Because MGA powder reacts with moisture by clogging dispersal equipment, the MDS requires sheltering from rain or snow. To provide this weather protection, it was decided to package the MDS in a small enclosed trailer. Based on the dimensions of the Rockduster components and space required for their operation, a 2 x 4 x 2 m (7 x 12 x 6 ft/6 in.), tandem-axle utility trailer (Wells Cargo, Inc., Elkart, Indiana) was selected. This trailer is equipped with a four-wheel, large hydraulic brake system and a jack-ram hoist coupling system. The 2 x 4 m (7 x 12 ft) trailer design allows for easy towing by a three quarter-ton pickup truck or other vehicle equipped with a 5-cm (2-in.) ball hitch and capable of towing 1400 kg (3080 lbs).

TRAILER MODIFICATION

Wells Cargo, Inc., the trailer manufacturer, modified the basic utility trailer unit (Model No. UT-12) according to MDS design specifications to include double rear doors, awnings, roof vents, dome lights, and a double door on the right front corner. The MDS design contains sufficient access doors and openings to operate and maintain MDS components, to provide ventilation for the air-cooled engine, and to minimize MGA dust in the operating area (Figure 1).

MDS ASSEMBLY

In designing and building the MDS unit, the weight of the Rockduster, engine, and hydraulic reservoir were distributed so that the utility trailer hitch did not exceed a 54-kg (120-lb) tongue load. The balance point for a tandem-axle trailer was located between the axles to divide the total volume of compartment space into a 60-40 ratio.

To balance weight load and maintain tongue load capacity, the hydraulic oil reservoir and engine/hydraulic pump unit were offset from the area above the tandem axle to the rear of the trailer. Figure 2 shows the component weight distribution used to maintain a tongue weight of 45 kg (100 lbs). With this configuration, both the reservoir and engine were made accessible by the double rear doors and through a 66-cm (26-in.) walkway between the units. As shown in Figure 1, the Rockduster was installed across the front of the utility trailer compartment so that the MGA delivery hose can be run through the front corner double doors.

The hydraulic oil reservoir was fitted with a Multiport, dual-element suction line filter (AMBAC Industries, Inc., Wheeling, Illinois), a Maxiflow return line filter (UCC, Inc., Cleveland, Ohio), a filter gage (UCC, Inc., Cleveland, Ohio), and a filler breather cap. The reservoir unit was then mounted in the left-rear section of the trailer compartment, 25 cm (10 in.) from the rear doors. The hydraulic system was filled with 151 liters (40 gal) of Mobil 10W30 motor oil. With filters and gages, the hydraulic

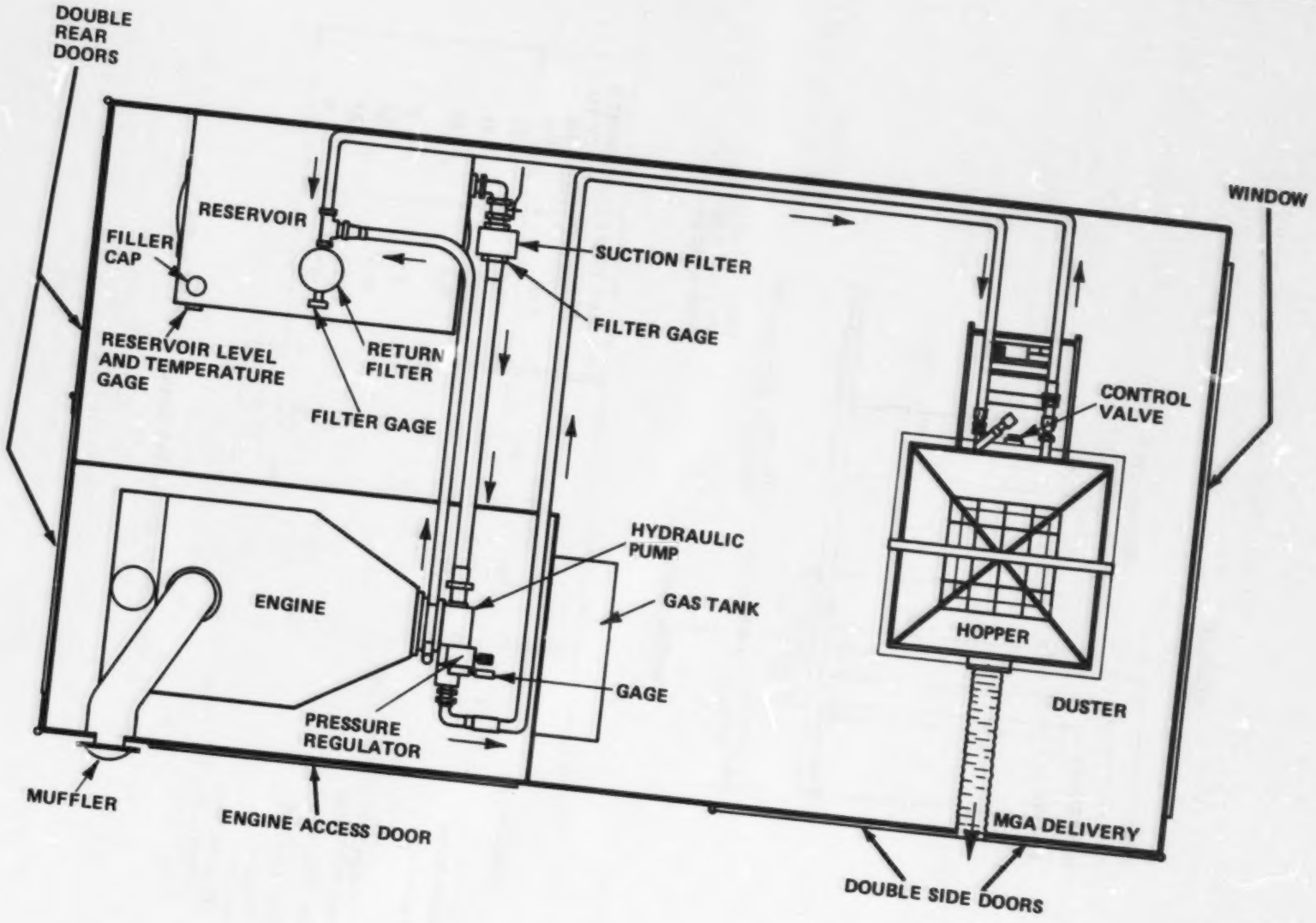
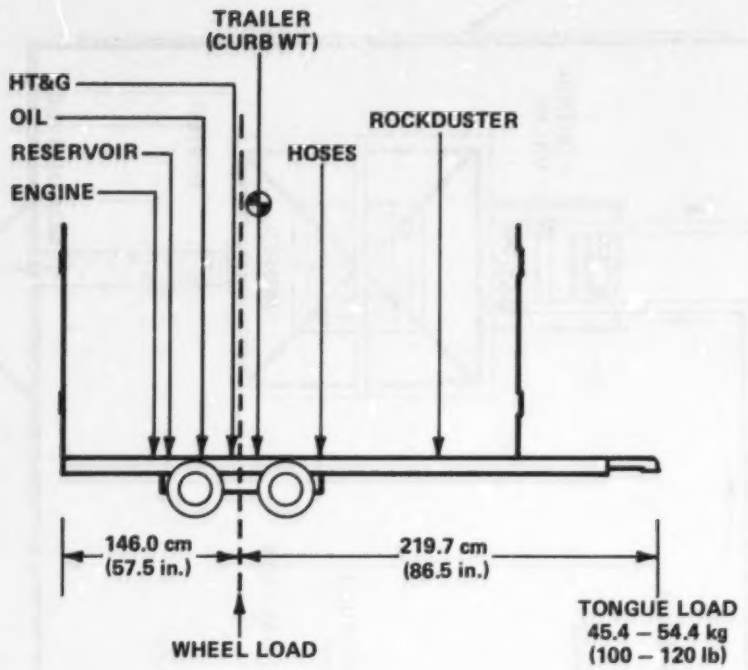


Figure 1. Floor plan and hydraulic system.



COMPONENT	WEIGHT (kg)	WEIGHT (lb)	DIST. FROM COMPONENT'S CENTER OF GRAVITY TO WHEEL LOAD LINE (cm)	DIST. FROM COMPONENT'S CENTER OF GRAVITY TO WHEEL LOAD LINE (in)
ENGINE/PUMP	145.2	320	58.4	23
RESERVOIR	88.5	195	53.3	21
OIL	145.7	320	35.6	14
HYDRAULIC TUBING, GAGES, AND FITTINGS	140.6	310	2.5	1
MGA DELIVERY HOSES	40.8	90	81.3	32
ROCKDUSTER	142.9	315	94.0	37
TRAILER	657.7	1,450	15.2	6
TOTAL WEIGHT	1,360.9	3,000		

Figure 2. Component weight distribution for MDS trailer.

reservoir as shown in Figure 3, weighs approximately 89 kg (195 lbs).

The 22.4-kW (30-HP) gasoline engine was mounted in the right-rear section of the trailer compartment, 31 cm (12 in.) from the double rear doors, and isolated with a plywood enclosure. The engine exhaust pipe and a noise muffler were then connected to the upper-rear corner of the trailer wall. The engine housing has an outside access door for maintenance work and also opens to the outside at the rear of the trailer to cool the engine and ventilate fumes when in use.

After mounting the engine, the single stage, 31.8 cm^3 (1.94 cu in.) displacement hydraulic pump was adapted to the engine drive. Total approximate combined weight of the hydraulic pump/engine unit, which is shown in Figure 4, is 145 kg (320 lbs). Figure 5 shows a detailed view of the hydraulic pump.

Buna-N 2.5-cm (1-in.) ID tubing was installed under a raised floor in the front of the trailer compartment to connect the hydraulic pump and reservoir with the Rockduster unit.

The hopper was fitted with an overlapping plexiglas cover to minimize MGA powder from blowing throughout the work area during operation. A control valve near the hopper permits ease of operation of the MGA blower and auger. The work area is ventilated by the front awning opening and corner double doors. The Rockduster unit, shown in Figure 6, weighs approximately 143 kg (315 lbs).

The interior of the assembled MDS unit is shown in Figure 7. Figure 8 shows the MDS trailer with a typical tow vehicle.

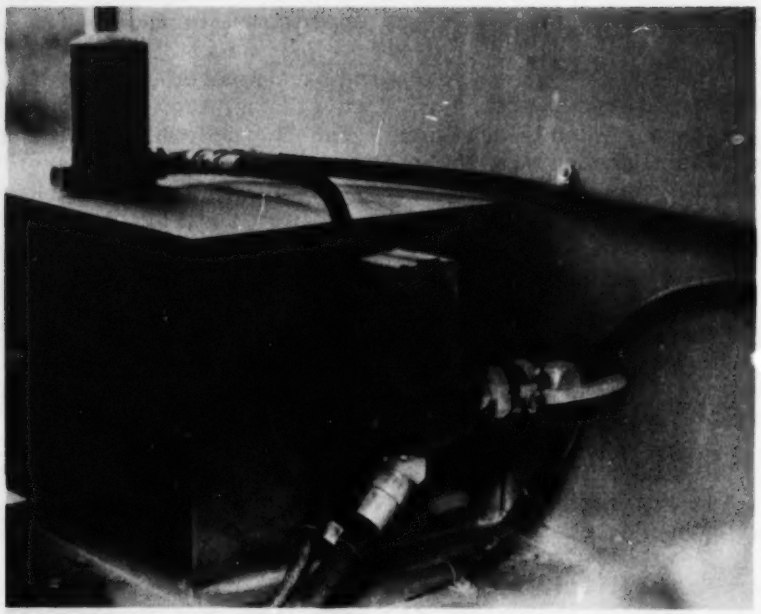


Figure 3. Hydraulic reservoir unit.

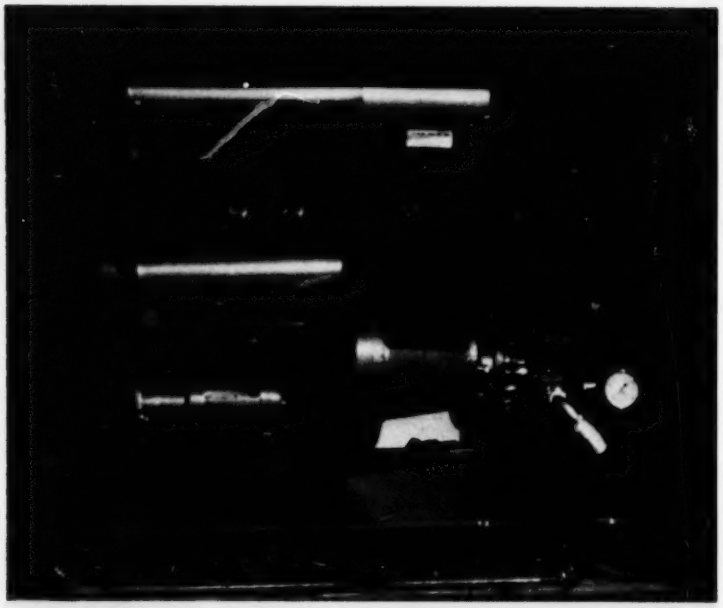


Figure 4. Hydraulic pump/engine unit.

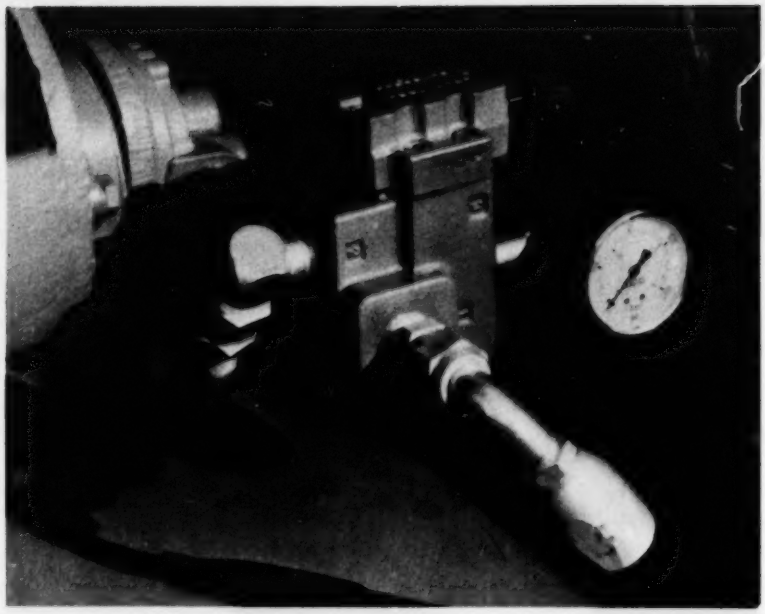


Figure 5. Hydraulic pump.

Figure 6. Rockduster distributor unit.

Figure 7. Interior view of MDS trailer.

Figure 8. MDS unit with towing vehicle.

SECTION 4

TESTING AND DEMONSTRATING

TEST SITE PREPARATION

Calspan modified a company-owned facility in Bethany, New York so that chemical test spills could be treated using the Mobile Dispensing System (MDS) prototype and demonstrations could be performed for Environmental Protection Agency (EPA) representatives. The Bethany test site configuration is illustrated in Figure 9.

Spill tests were performed in three 23-m (75-ft) ditches that sloped at a 1% slope and terminated in 4-m (12-ft) diameter pools. The trench configuration allowed spill tests to simulate both stream and shallow pool conditions. Test site modification consisted of reworking old trenches to remove eroded soil and digging new shallow pools at the end of each trench.

FIELD TESTING

In developing guidelines for the MGA program, each of the 35 hazardous compounds tested were classified as either an aqueous solution, nonpolar organic material, polar organic material, or alcoholic material. Small-scale spill tests were planned to include one chemical compound from each of these classes. Evaluators also planned to simulate a major chemical spill of approximately 950 liters (250 gal) using dyed water adjusted to pH 3.0 with sulfuric acid. Prior to testing, Calspan ordered enough material to prepare 1204 kg (2655 lbs) of Blend D. Blending was performed by the Riverside Chemical Company using a Marion mill. The final blend was packaged in 14-kg (30-lb) containers. (Blending specifications are included in Appendix A.)

The MDS was performance-tested by expelling agent over a 6 x 6 m (20 x 20 ft) plastic sheet to determine its dispersion pattern and maximum delivery rate. At maximum throttle the MDS unit delivered approximately 5.4 kg (12 lbs) of agent per minute to the test target area. With the exit nozzle held 1.2 m (4 ft) above the ground, the MDS unit distributes 85 percent of the MGA over distances from 2 to 6 m (6 to 20 ft) as shown in Figure 10.

Testing of MDS on small liquid spills began 21 October 1976. Temperatures during testing were near 0°C (32°F). The first spill consisted of pouring 76 liters (20 gal) of water into a linear ditch 76-cm (30-in.) wide. After 15 seconds of spilling, MGA was applied to the head of the spill, containing the flow in 2 m (8 ft) and using 9 kg (20 lbs) of agent. When

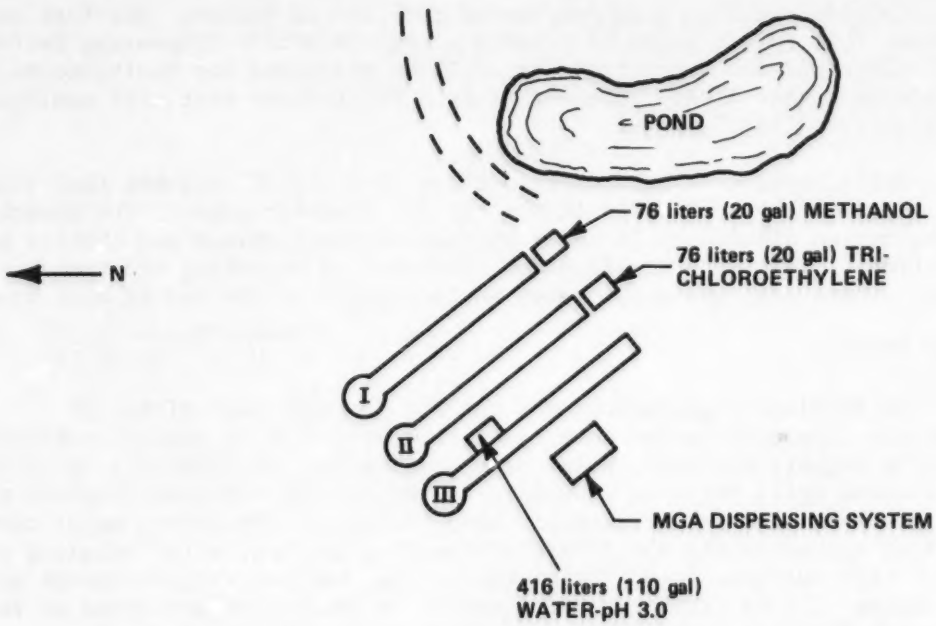


Figure 9. Demonstration spill site, Bethany, New York.

kerosene was tested under similar conditions, MGA contained the spill in 6 m (20 ft) using 41 kg (90 lb) of agent. A flow of trichloroethylene was gelled in 6 m (20 ft) using 18 kg (40 lb) of MGA. The alcohol, methanol was also contained in 6 m (20 ft) with a 20 kg (45 lb) application of MGA. Further information on the minor spill tests is presented in Table 1.

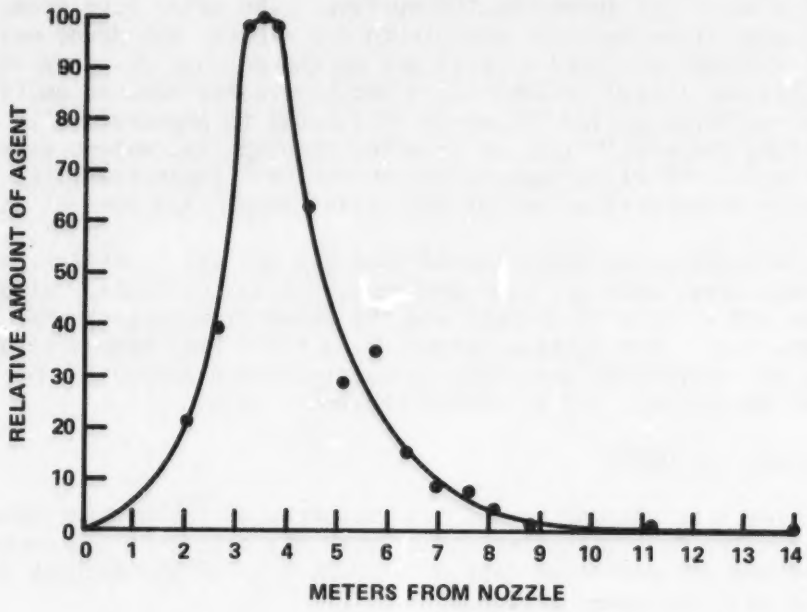


Figure 10. MGA dispersion pattern vs distance (exit nozzle 1.2 meters above and parallel to the ground).

Table 1
76-LITER (20-GAL) CHEMICAL SPILLS

CHEMICAL	CLASS	SPILL RATE liter (gal)/min	MGA USED kg (lb)	AMOUNT OF MGA USED PER LITER SPILLED kg/liter	DISTANCE SPILL STOPPED m (ft)
WATER**	AQUEOUS	151.4 (40)	9.1 (20)	0.12	2.4 (8)
KEROSENE*	HYDROCARBON	151.4 (40)	40.8 (90)	0.54	6.1 (20)
TRICHLOROETHYLENE*	CHLORINATED	151.4 (40)	18.1 (40)	0.24	6.1 (20)
METHANOL*	ALCOHOL	151.4 (40)	20.4 (45)	0.27	6.1 (20)

*AIR TEMP 0°C, WIND 8-16 km/hr
**AIR TEMP 7°C, WIND 8 km/hr

To test MGA performance on a major spill, 946 liters (250 gal) of a simulated toxic substance were poured into a 76-cm (30-in.) wide trench running 9 m (30 ft) into an open pool area. The simulant consisted of water dyed with Rhodamine WT and adjusted with sulfuric acid to pH 3.0. Six 208-liter (55-gal) drums of the toxic simulant were arranged in a pyramid at the end of the trench. The center drum was opened first and treated with MGA until a stiff gel formed on the surface. The other five drums were opened as quickly as possible and within two minutes all drums were emptied. Treatment with MGA produced a stiff gel on the surface [5-10 cm (2-4 in.)] of the spill but failed to immobilize depths greater than 10 cm (4 in.). After the top layer gelled, it became difficult to penetrate with additional MGA, limiting the possibility of treating deep spills, unless external mixing can be provided. Earlier experiments showed that impenetrability can also be partially alleviated by use of the rolled compressed form of the agent.[2]

These field experiments showed that the MDS can be effectively operated by a two-man crew, with one crew member operating the mechanical portion of the system and filling the hopper and the other directing the MGA onto the spilled material. For optimum operation, a third crew member is useful for directing the operation, assisting in maintaining a supply of MGA filled drums near the hopper, and recording treatment data.

DEMONSTRATION FOR USEPA

A major spill demonstration was conducted at the Bethany site on 4 November 1976, to acquaint attendees with the operation and capabilities of MGA and the MDS prototype design. Figure 9 shows the Bethany demonstration site. Attendees included:

Ronald Hill, Director, Resource Extraction and Handling Division, IERL-USEPA, Cincinnati, Ohio

Joseph Lafornara, Project Officer, USEPA, Edison, New Jersey

Chester Marcyn, Region 5, USEPA, Chicago, Illinois

Thomas Smith, Research Engineer, Public Technology, Inc., Washington, D.C.

The demonstration program included a briefing in which design characteristics of the MDS unit were presented and system modifications, such as the addition of wind-monitoring equipment, were proposed.

In the initial demonstration, 76 liters (20 gal) of methanol were spilled into a linear ditch and immobilized in 3.3 minutes with a 20-kg (45-lb) application of MGA. The second demonstration consisted of spilling and gelling 76 liters (20 gal) of trichloroethylene. Gelling for this second spill was completed in 3 minutes with 18 kg (40 lb) of agent. After both minor spills, observers were allowed to examine the consistency of the gelled material.

Figure 11 shows a team member applying MGA to a minor spill. Figure 12 shows the immobilized spill material after agent has been applied.

For the major spill demonstration, 416 liters (110 gal) of a simulated toxic substance were poured down 9 m (30 ft) of linear ditch to a 3 m (10 ft) pooling area. The simulant consisted of water which had been dyed red with Rhodamine WT and adjusted to pH 3.0 with sulfuric acid. The demonstration team immobilized this major spill in 8 minutes with 34 kg (75 lb) of MGA. After treatment, the consistency of the gelled materials was tested.

The ground at the spill site was frozen on the day of the demonstration with the surface thawing gradually under sunny skies. Air temperature was 40°C (22°F) and wind speed 8-16 km/hr (5-10 mph).

Following all tests and demonstrations, team members shoveled the gelled chemicals into 208-liter (55-gal) drums; the material was then sent to an approved landfill for proper disposal.

FILM DOCUMENTATION

Each of the chemical spills during the testing and demonstration was documented on 35mm slide film and 16mm motion picture film. Calspan Corporation used this documentation to produce a slide/tape presentation and a 10 minute motion picture demonstration film in fulfillment of the contract.

OPERATION AND MAINTENANCE MANUAL

In fulfillment of requirements for EPA Contract No. 68-03-2093, Calspan Corporation compiled an operation and maintenance manual for the MDS prototype. This manual contains a complete unit description, and start-up and dispensing instructions. Individual components of the MDS unit are described in vendors' literature incorporated as appendices to the manual, which is available from the Oil and Hazardous Materials Spills Branch of the USEPA's Industrial Environmental Research Laboratory at Cincinnati.

MDS MODIFICATION

Safety modifications were added to the MDS prototype design based on suggestions made during the testing and field demonstration programs. These modifications included the addition of a nonslip floor to the hopper work area and relocation of the gas tank to the opposite side of the partition wall from the engine. The separating wall between the gas tank and engine reduces the effects of engine heat on the fuel supply and makes the tank easily accessible from the front corner door.

Two brackets were mounted on the trailer sidewall near the Rockduster for hanging 15-m (50-ft) and 31-m (100-ft) coils of 5-cm (2-in.) ID MGA delivery hose. A mast was attached to the top of one outside wall to hold optional wind-monitoring equipment.

Figure 11. Operator dispensing MGA.

Figure 12. Immobilized spill material.

REFERENCES

1. Pilié, R.J., Baier, R.E., Ziegler, R.C., Leonard, R.P., Michalovic, J.G., Pek, S.L., Bock, D.H. "Methods to Treat, Control and Monitor Spilled Hazardous Materials" EPA-670/2-75-042 U.S. Environmental Protection Agency, June 1975. 138 pp.

2. Michalovic, J.G. et al. "Multipurpose Gelling Agent and Development of Means of Applying to Spilled Hazardous Materials." EPA Report No. 600/2-77-151, U.S. Environmental Protection Agency, Cincinnati, Ohio January 1977. 46 pp.

APPENDIX 1

BLENDING SPECIFICATIONS FOR MULTIPURPOSE GELLING AGENT-BLEND D

MGA, Blend D, is a balanced blend of four organic polymers and a fumed silica. This blend in previous testing[2] showed the most promise to immobilize the largest number of chemical compounds with approximately the same amount of agent. The formulation of Blend D follows:

Trade Name	Manufacturer	% Composition by Weight
Norback*	Dow Chemical Corp.	5
Imbiber Beads	Dow Chemical Corp.	30
Hycar 1422	B.F. Goodrich Corp.	30
Carbopol 934	B.F. Goodrich Corp.	25
Cabosil	Cabot Corp.	10

*Equivalent to Gelgard M (Dow Chemical Corp.)

To blend, the percentage by weight of each component is placed in a sealed Marion mill and the mass blended for 30 minutes or until homogeneous. The blended agent is to be stored in moisture-proof containers until used.